Transferability of Travel Survey Data: A Household Travel Data Simulation Tool

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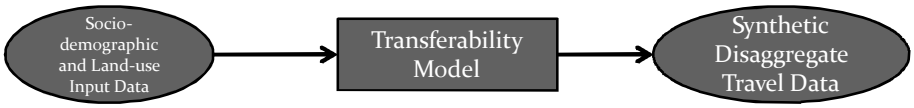
Objectives

- Examine the feasibility of data transferability approach as an alternative to costly travel surveys
- Develop a comprehensive travel data transferability model
- Develop a software tool to facilitate travel data transferability
  - simulate synthetic household level disaggregate travel data
- Test and validate the model
  - Two case studies: Des Moines, IA and New York State
- Examine the model for sensitivity analysis
  - scenarios such as changes to the demographics, aging population, and investments in the education system.

UIC Transferability Tool



Input Data:

- Socio-Demographic Information of Households
  - Usually comes from population synthesizer
- Land-use Characteristics of Residential locations
  - Embedded in the software for all census tracts in US

Input Data 1:

- Socio-Demographic Information of Households
  - Education Level
  - Type of Job
  - Type of Ethnicity
  - Household Size
  - Household Income
  - Number of Vehicles
  - Number of Workers
  - Number of Adults

Input Data 2:

- Land-use Characteristics:
  - Housing density, Employment density, Population density
  - Transit usage (Compiled from CTPP 2000)
  - Travel-Time Index (from TTI report)
  - Intersection density
  - Road density
  - Pedestrian friendly environment (Block size)

UIC Transferability Model

- NHTS 2001 households were clustered into 11 clusters, according to their life-style
- At each cluster, many distributions were fitted on travel attributes, and the parameters of best ones are used to generate travel attribute for other regions
- A neural network model is used to replicate the clustering
- Monte-Carlo simulation is then used to generate travel attributes of the households (Drawing from the selected distribution)
- Updating methods are suggested in case more information of the application region is available (local sample or expert's opinion)
- For more information please refer to:

Mohammadian, A. and Y. Zhang. Investigating the Transferability of National Household Travel Survey Data, in Transportation Research Record: Journal of the Transportation Research Board, No. 1993, TRB, 2007, pp.67-79.

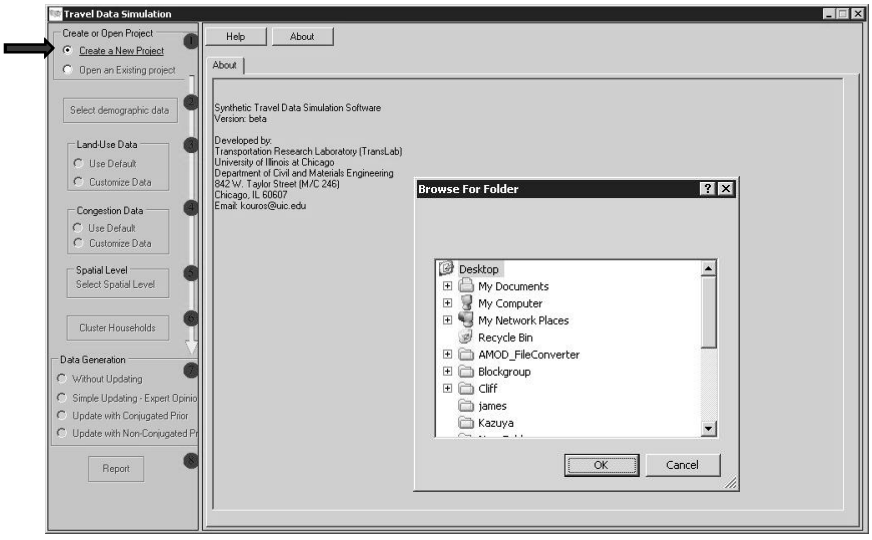
Output:

- Nine travel attributes for every household
  - Total number of trips
  - Number of auto trips
  - Number of mandatory trips
  - Number of maintenance trips
  - Number of discretionary trips
  - Number of tours
  - Average number of trips per tours
  - Average trip miles traveled
  - Average commute distance
- Can be aggregated at any spatial level

Using Transferability Software: 8 Steps

- Create/open a project
- Import socio-demographic information
- Use provided land-use data or import your own
- Use provided congestion index or import your own data
- Select spatial level of each type of input data
- Cluster the households
- Generate Travel attributes
- Generate reports

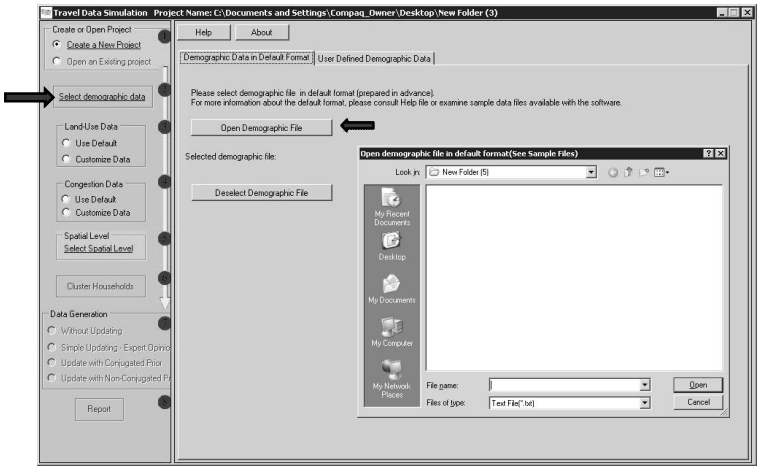
Step 1: Create/open a project



Step 2: Import socio-demographic information

- Includes a list of households, their residential location and socio-demographic information
- Usually compiled from population synthesizers' output
- Text file format

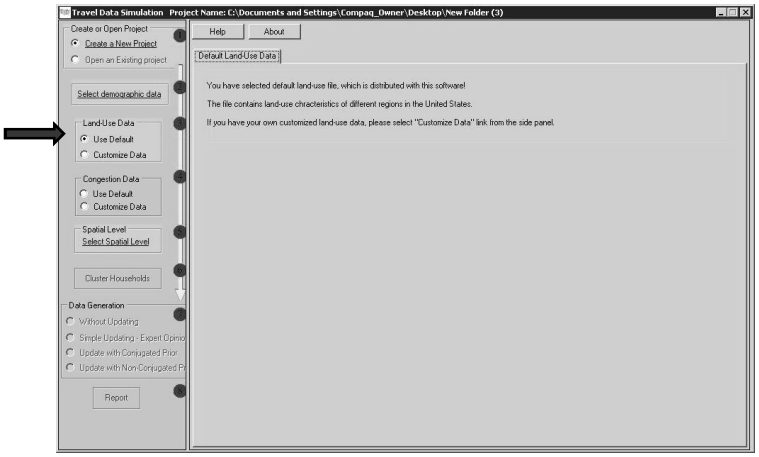
Step 2: Import socio-demographic information



Step 3: Use the land-use data provided

- Currently land-use characteristics at Census Tract (CT) level are embedded in the software.
- For most applications, the embedded information can be used.

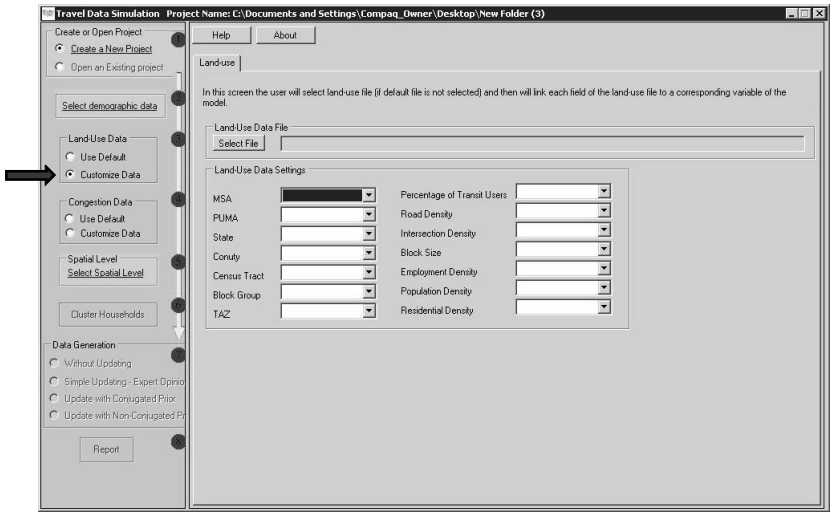
Step 3: Use the land-use data provided



Step 3: Import your own land-use data

- If more recent land-use information is available, it can be imported and used in the analyses.
- Also if further detailed information (e.g. Block Group level characteristics) is available, it be imported as well.

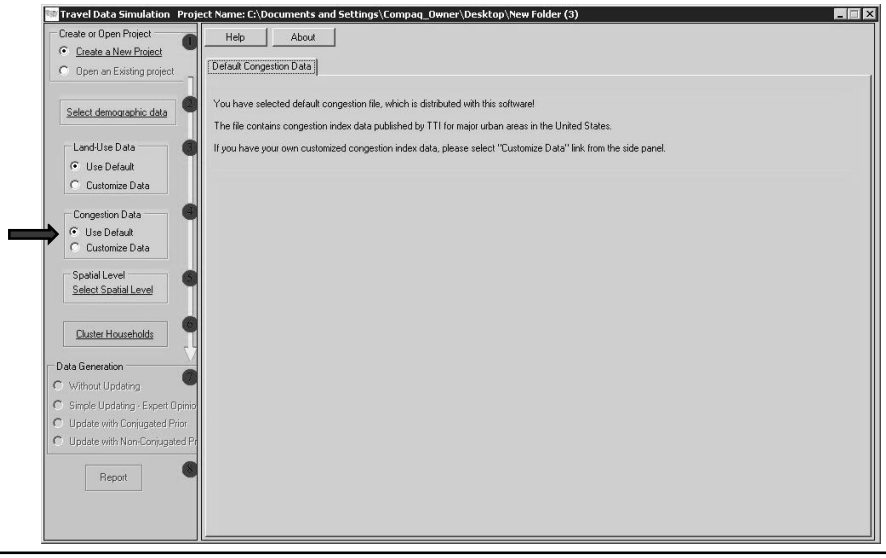
Step 3: Import your own land-use data



Step 4: Use provided congestion index

- For most applications, there is no need to import any data.
- Embedded information (from TTI annual mobility report) can be used.

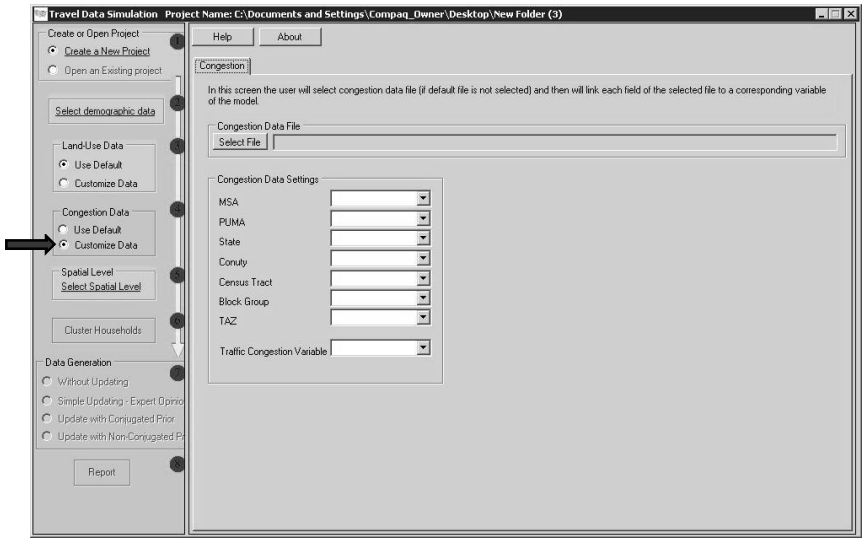
Step 4: Use provided congestion index



Step 4: Import your own congestion index

- The provided file, includes Travel Time Index of 85 urban areas (MSA). If more recent data is available, it can be imported.
- Also if further detailed information (e.g., Census Tract level) is available, it can be imported as well.

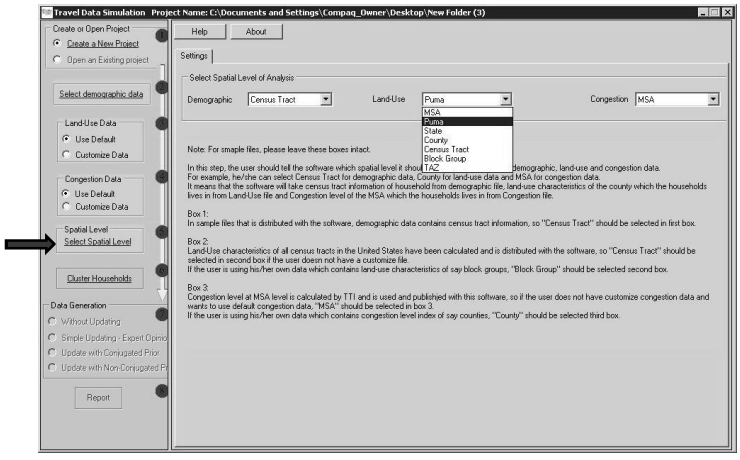
Step 4: Import your own congestion index



Step 5: Specifying spatial level of input data

- The default spatial level of data are:
  - Demographic data: Census Tract
  - Land-Use data: Census Tract
  - Congestion: Urban Area
- If other spatial levels are used, they should be identified in this step

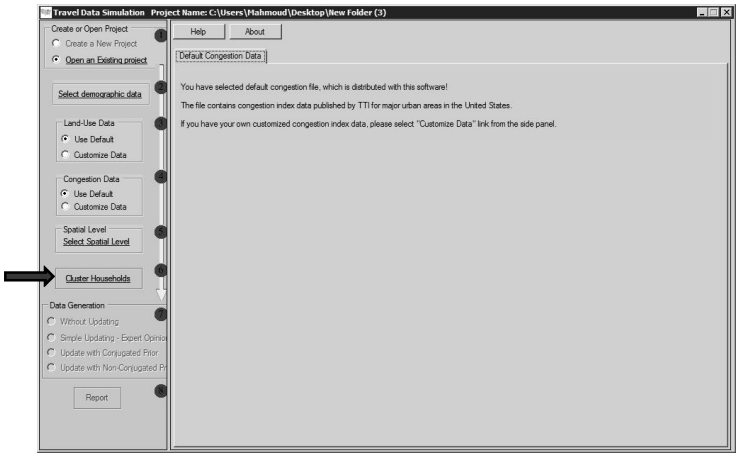
Step 5: Specifying spatial level of input data



Step 6: Clustering the Households

- In this step, the software combines the input data to assign cluster membership (lifestyle) to each household.
- The output is a text file, including a list of households along with their characteristics and cluster numbers.

Step 6: Clustering the Households



Step 7: Generating Disaggregate Travel Data

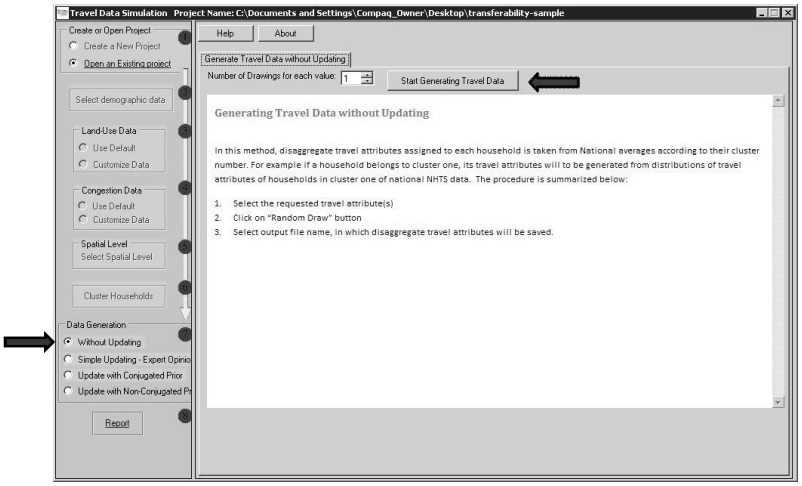
- Predefined distributions are used to generate synthetic travel data
- Four options for generating travel data are offered in the software:
  1. Without updating
  2. Updating parameters of distributions using an expert's opinion
  3. Updating parameters of distributions using mean and sample size of a local sample and Bayesian updating method (Conjugated)
  4. Updating parameters of distributions using a local sample and Bayesian updating method (Non-Conjugated)

Step 7: Generating Disaggregate Travel Data

- Method 1: Using predefined distributions (without updating)
  - For each travel attribute and across the 11 clusters, the program uses a random number generator to draw a set of random numbers from appropriate distributions and assigns them to the households.
  - Best fitted distributions are embedded into the software.

Step 7: Generating Disaggregate Travel Data

- Method 1: Using predefined distributions (without updating)

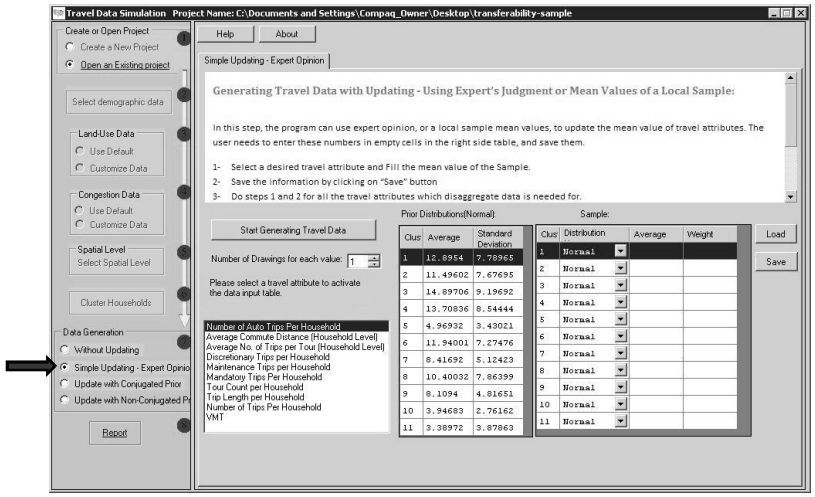


Step 7: Generating Disaggregate Travel Data

- Method 2: Expert's opinion updating
  - Just an estimate of average values of travel attributes, at each cluster, is needed for the application region
  - They are used to update the parameters of the distributions that were fitted on national level travel data.
  - Travel attributes are drawn from normal or gamma distribution (Gamma fits reasonably well on reported travel attributes)

Step 7: Generating Disaggregate Travel Data

- Method 2: Expert's opinion updating

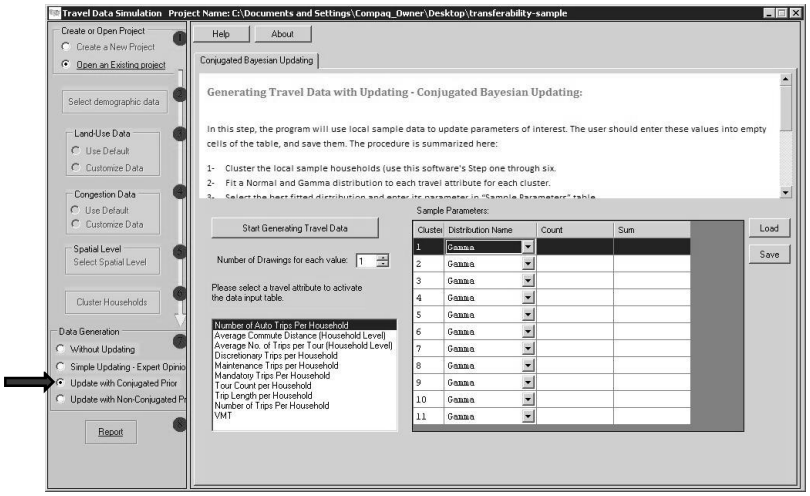


Step 7: Generating Disaggregate Travel Data

- Method 3: Bayesian updating -Conjugated
  - Bayes theorem is used to take advantage of a local sample to update the parameters of the distributions that were fitted on NHTS 2001 national travel data.
  - Bayesian updating for gamma and normal distributions have closed forms and could be incorporated into the software.
  - Just basic statistics (average and sample size) of the local sample is needed to apply this method.

Step 7: Generating Disaggregate Travel Data

- Method 3: Bayesian updating –conjugated

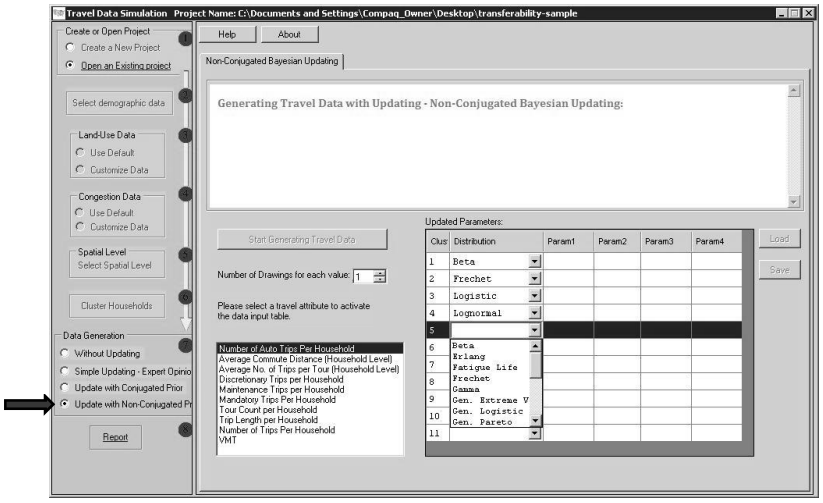


Step 7: Generating Disaggregate Travel Data

- Method 4: Bayesian updating –Non Conjugated
  - For most distributions there is no closed form formula for updating the parameters, therefore advanced Bayesian updating software tools should be employed.
  - The user needs to update the parameters of the distributions using a professional software (e.g., WinBUGS), and enter the results into the transferability software in order to generate disaggregate travel data.

Step 7: Generating Disaggregate Travel Data

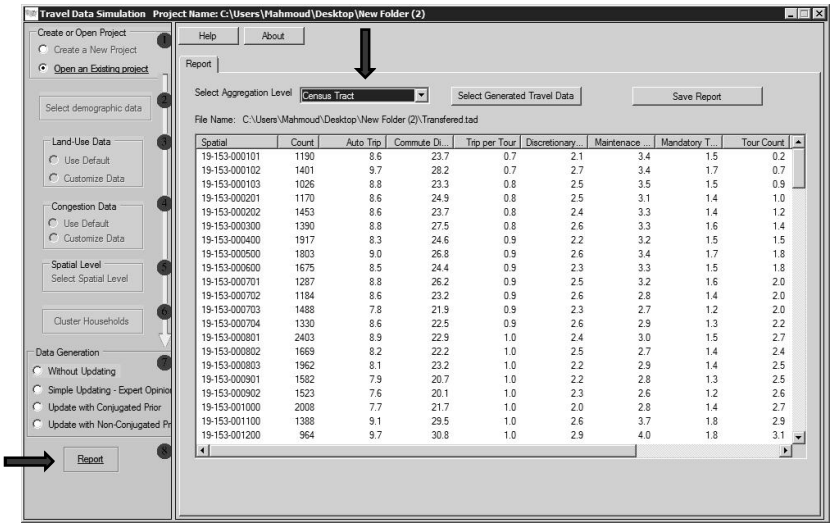
- Method 4: Bayesian updating –non conjugated



Step 8: Generating Reports

- The output of previous step is a text file including a list of households along with:
  - Their socio-demographic attributes
  - Land-use characteristics of their residential locations
  - Their lifestyle (i.e., cluster number)
  - Their synthetic travel data
- The software can generate aggregate reports at any spatial level (state, county, census tract, block group, and TAZ)

Step 8: Generating Reports



Validation

- The model was used to generate travel attributes of two regions (a mid-size and a large area):
  - Des Moines, IA and the state of New York
- The results were validated against corresponding NHTS 2001 add-ons

Des Moines Observed, Transferred, and Updated Travel Attributes (first 3 clusters)

Cluster	Case	Number of Households	Auto Trip	Commute Distance	Trips per Tour	Discretionary Trips	Maintenance Trips	Mandatory Trips	Tour Count	Trip Length	Trip Rate
1	Observed	68	12.4	23.1	1.3	4.2	2.8	1.9	11.0	141.3	13.8
	Transferred	10278	7%	9%	9%	-13%	**48%**	13%	-1%	**-20%**	10%
	Updated	10278	1%	-5%	1%	-5%	20%	2%	0%	-16%	1%
2	Observed	138	10.2	18.9	1.3	2.9	2.8	1.5	8.5	94.3	11.2
	Transferred	39153	13%	**78%**	4%	5%	**30%**	**32%**	11%	**22%**	14%
	Updated	39153	-1%	12%	1%	-2%	1%	9%	-2%	3%	-1%
3	Observed	104	15.6	27.4	1.4	4.9	4.2	2.3	12.7	158.4	17.3
	Transferred	11214	-4%	13%	1%	-14%	14%	5%	-3%	-14%	-1%
	Updated	11214	-4%	-7%	-1%	-7%	2%	-5%	-1%	-9%	-2%

New York Observed, Transferred, and Updated Travel Attributes (first 3 clusters)

Cluster		Number of Households	Auto Trip	Commute Distance	Trips per Tour	Discretionary Trips	Maintenance Trips	Mandatory Trips	Tour Count	Trip Length	Trip Rate
1	Observed	738	12.3	34.6	1.4	3.6	3.9	2.1	10.5	121.1	14.5
	Transferred	190,171	7%	-27%	-1%	3%	7%	2%	4%	-7%	3%
	Updated	190,171	3%	-1%	-1%	4%	4%	2%	4%	0%	3%
2	Observed	889	10.0	24.2	1.4	2.6	3.4	1.8	8.5	94.5	11.8
	Transferred	444,173	14%	**38%**	-1%	16%	9%	8%	10%	20%	9%
	Updated	444,173	-1%	2%	1%	-2%	-2%	3%	-2%	-2%	-2%
3	Observed	801	13.1	31.0	1.4	3.6	4.2	2.3	11.4	129.5	15.7
	Transferred	255,182	14%	0%	-1%	15%	13%	5%	8%	7%	9%
	Updated	255,182	0%	-2%	-1%	2%	-1%	-1%	0%	-2%	-1%

Software

- The software is available for download from:
  - http://www.nationaltraveldata.com
- Two synthetic population sample files are also available for download to test the software

Population Synthesizer

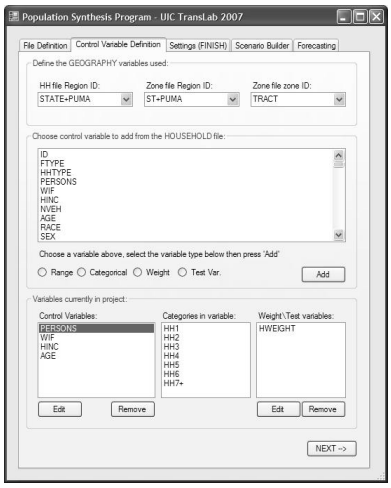
Synthesis Methodology

- Procedure (for each zone, i.e. block group, census tract, etc.:
  - Get joint distributions from sub-region level (PUMS) data
  - Fill zonal joint distributions (household and person) from sub-region
  - Fit joint distribution to zonal marginals (SF_3) for hh and person using IPF procedure
  - For each household in the PUMS sample (drawn randomly):
    - attempt to add x times with probability p
    - x = number of remaining households to create with the same type as the current household (from IPF)
    - P = household selection probability weighted by fit to person distribution (shown below)
    - Update x and p each time household (and persons in household) are added
  - Ensures fit to both the household and person distributions with minimal iteration through household list (only one iteration required if rounding/integerization effects ignored)

Population Synthesizer

Base Population Synthesis Program

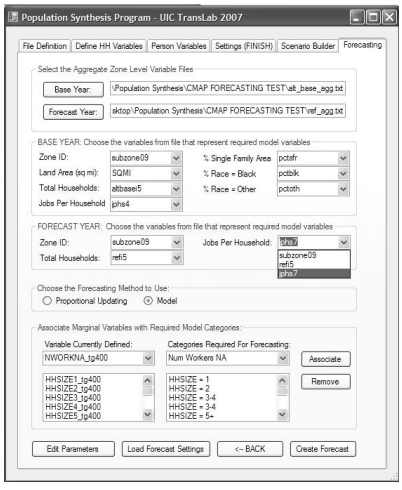
- Allows any geography and control variable for which data exists
- Up to nine controls at household and person level simultaneously
- Synthesis routine:
  - IPF at household/person level
  - Household selection weighted based on person fit
- Output statistics include:
  - Marginal fit for controlled / uncontrolled variables
  - Statistical tests on synthesized joint distributions
- Fast visualization of results



Population Synthesizer

Forecasting Control Variables

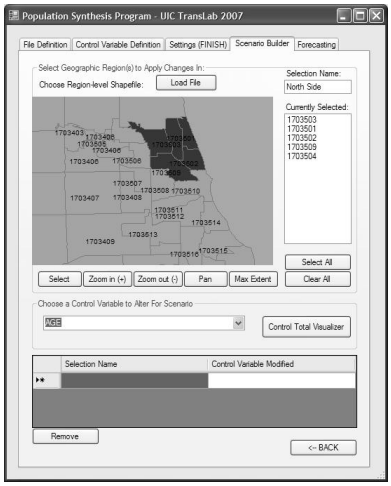
- Input base and forecast year required zonal data
- Link control variable categories to forecast categories
  - 4 HHsize, 3 numworkers
- Generate forecast marginals:
  - Proportional updating, or
  - Forecast model

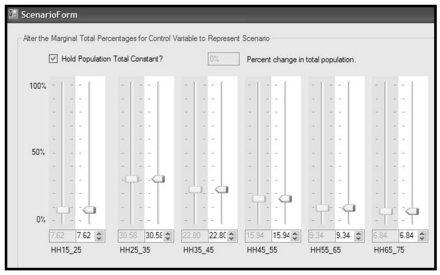


Population Synthesizer

Scenario Definition

- Select sub-regions to apply changes
- Select control variable to modify
- Adjust variable marginal distribution
- Multiple selections, modified variables allowed





Population Synthesizer

Benefits of Population Synthesis Program

- Very general:
  - Not restricted in terms of geographic applications
  - Any control variables can be used (given appropriate data)
  - Other applications besides Household/Person synthesis
- Multilevel controls:
  - More control over synthesized population, less person-level error
- Implementation of efficient selection procedure:
  - Reduces run-time to <2 sec/zone (in many instances)
    - for average of 2,000 synthesized households per zone
- Standard output statistics allow for comparisons of different synthetic populations, fine-tuning of final result

Questions?